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From: Commander, Naval Air Systems Command

Commander, Aeronautical Systems Center
Commander, Army Aviation and Troop Command
Commander, Defense Contracts Management Command
Chief, Office of Engineering and Logistics Development, United States Coast Guard
Administrator, National Aeronautics and Space Administration

Subj JOINT AERONAUTICAL COMMANDERS GROUP ADVANCED QUALITY GUIDE

Ref: (a) Joint Aeronautical Commanders Group ltr of 12 Dec 94, Subject: Policy for the Use of ANSI/ASQC Q9000 Series Quality Standards
(b) NASA Quality Management System Policy (ISO 9000) of 6 Dec 95 USD(AT) memo of 14 Feb 94, Subject: Use of Commercial Quality System Standards in the Department of Defense
(d) SECDEF memo of 29 Jun 94, Subject: Specifications and Standards -- A New Way of Doing Business

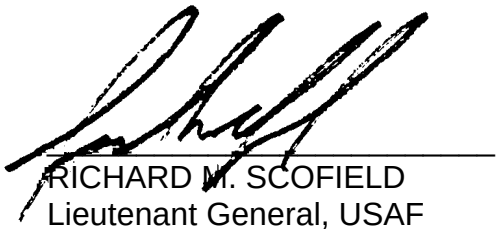
Encl (1) Advanced Quality: A Guide for Aerospace Acquisition Management Teams
(2) Advanced Quality Points of Contact

1. The Joint Aeronautical Commanders Group (JACG) policy of references (a) and (b) establish the ANSI/ASQC Q9000 series as the basic minimum quality system model for member buying activities. Reference (a) explicitly encouraged supplementing Q9000-based quality systems with advanced quality techniques that focus on preventing defects through influencing the development of the design and manufacturing processes. To facilitate the understanding and use of advanced quality approaches by JACG buying activities, the JACG has prepared the enclosure (1) policy guide.

2. By design, enclosure (1) is strictly for internal government use only; it will NOT be cited or referred to in contractual documents. It is not a “quality standard" or specification. Enclosure (1) implements the acquisition reform policies of references © and (d) by recommending a departure from the traditional approach for communicating expectations to potential contractors. Instead of prescribing detailed contractual requirements, enclosure (1)

emphasizes identifying and selecting those offerors who propose effective advanced quality systems. Experience has shown that the award of new business strongly motivates companies to implement such systems.

3. JACG points of contact for advanced quality questions are found in enclosure (2).



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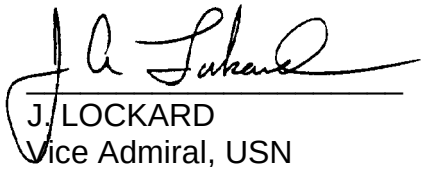
Lieutenant General, USAF



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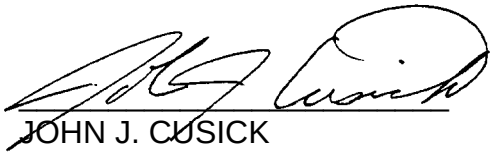
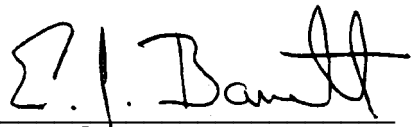
Vice Admiral, USN

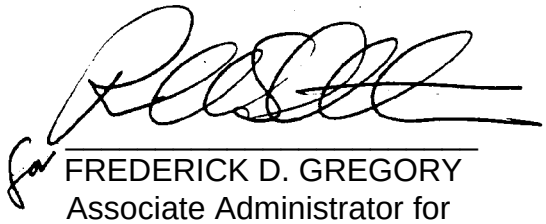


JOHN J. CUSICK
Major General, USA

ROBERT DREWES
Major General, USA



EDWARD J. BARRETT
Rear Admiral, USCG



for FREDERICK D. GREGORY
Associate Administrator for
Safety and Mission Assurance,
NASA

JOINT AERONAUTICAL COMMANDERS GROUP

ADVANCED QUALITY:

A Guide For Aerospace Acquisition Management Teams

Enclosure (1)

ADVANCED QUALITY: A GUIDE FOR AEROSPACE ACQUISITION MANAGEMENT TEAMS

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APPENDICES

ADVANCED QUALITY: A GUIDE FOR AEROSPACE ACQUISITION MANAGEMENT TEAMS

1. BACKGROUND

Basic quality systems have traditionally focused on the identification and control of hardware that fails to meet specified requirements. A basic quality system functions properly when it precludes nonconforming hardware from getting into the hands of the customer. Identification of nonconforming material is usually accomplished through extensive inspection and testing. Once identified, the hardware is segregated and dispositioned through the preliminary review or material review board process, in which a determination is made whether the hardware should be used as is, reworked or repaired, or scrapped.

Although preventing nonconforming material from reaching the hands of the customer is a critically important function, the basic quality assurance approach suffers from a number of drawbacks. Foremost among these drawbacks is that the identification and correction of defects have proved to be much more costly than preventing their occurrence in the first place. Such activities as inspection, test, segregation and processing of nonconformances, and rework, each incur costs and yet add no value to the product. Secondly, inspection and test -- even when performed on a 100% basis -- often fail to identify all existing nonconformances. One hundred percent inspection has proved to be less than 100% effective in identifying defects. Lastly, the use of inspection and test as the principal means of determining product acceptability has frequently led to the perception that workers who perform such inspections and tests -- rather than those who design, fabricate and assemble the product -- are responsible for product quality.

Advanced quality systems (AQSs) contrast with basic systems by emphasizing the prevention of defects versus after-the-fact detection of defects. Advanced quality approaches emphasize quality in the development process to achieve producible designs and capable, controlled manufacturing processes. To achieve these objectives, AQSs also emphasize an integrated, multi-functional approach to quality throughout the product life cycle. Potential benefits directly attributable to the implementation of advanced quality practices include decreased cycle time as well as reductions in rework, engineering changes, and inspections and tests. These benefits translate into improved affordability and reduced production transition risk.

2. PURPOSE

Current JACG policy (Appendix A) establishes the ANSI/ASQC Q9000 series, or equivalent, as the basic minimum quality system models for member buying activities. The Q9000 series was written to provide the latitude of implementing either a defect detection or a defect prevention approach. To facilitate the understanding and use of advanced quality approaches, the JACG has prepared the guidance contained herein to assist in implementing requirements that build on those of Q9000.

Users of this document should note that the guidance contained herein departs from the traditional approach for communicating expectations to potential suppliers -- i.e., including a lengthy set of detailed model contract requirements in the procurement instrument. Rather, it emphasizes selection of suppliers who demonstrate that they have implemented effective AQSs. Experience has shown that award of new business is far more effective than simple contract requirements in motivating companies to implement such systems. The JACG intends for the guidance in this document to be used to (1) encourage offerors to describe in their proposals their approaches for achieving an advanced approach to quality; (2) identify and select offerors who propose credible advanced quality approaches; and (3) incorporate the advanced quality elements of the proposal into the final contract.

3. CONTENTS

The “Discussion” section, Section 4, describes the AQS process and explains why the AQS is important. Section 4 also describes various attributes, tools, and business practices associated with successful AQSs.

Following the Discussion section, each of the four major acquisition phases is addressed in the “Advanced Quality by Acquisition Phase” section, Section 5. For each phase, the broad objectives of an advanced quality system are defined and sample Statement of Objectives (SOO) / Statement of Work (SOW) language is provided. (In some activities, the SOO is replacing the SOW. Under Acquisition Reform, both the SOO and SOW are intended to communicate government expectations without providing prescriptive language.) For the development phases, which are assumed to be competitive for the purposes of this guide, the guide also provides recommended language for procurement instruments. For simplification, this guide refers to the Request for Proposal (RFP) structure of Sections C (SOO / SOW), L (the “Instructions, Conditions, Notice to Offerors”) and M (“Evaluation Factors for Award”).

Note: Development of methods for proposal verification, including use of certification programs/initiatives, is the responsibility of the procuring activity and is not discussed in this guide.

4. DISCUSSION

This section is intended to assist the reader in identifying some of the elements of an AQS and in understanding why an AQS is important to affordability and to mitigating the risks of transitioning to production. It provides a primer on Advanced Quality by introducing and summarizing some of the attributes, tools, and business practices associated with AQSs that may be applied to complex aerospace acquisition programs. The discussion does not provide an all-inclusive list of AQS elements, nor will all of the AQS tools discussed be appropriate for all acquisitions.

Given that equipment acquired by aerospace community buying activities includes everything from satellites and manned and unmanned vehicles to engines, avionics and ground support equipment, it should be obvious that there is no "one-size-fits-all" AQS. In addition, the summaries of tools, attributes and business practices contained herein do not provide sufficient detail to be the sole reference source for the uninformed reader. Users of this policy guide are strongly urged to gain a detailed understanding of these topics, as well as related quality assurance and management practices and philosophies, prior to applying any of the principles contained herein. Informed readers may wish to proceed directly to Section 5 for suggested RFP language, which should be tailored as appropriate for individual acquisitions.

4.1 SCOPE OF THIS GUIDE

Aerospace community acquisition management teams can consult this Guide in the planning process for nearly any development or production contract. The Guide's applicability, however, may vary depending on the program and acquisition process (particularly for acquisitions of Non-Developmental Items, Commercial Off-the-Shelf systems, purely build-to-print acquisitions such as reprocurements of spares and repair parts, and programs where only software or services (such as maintenance) are being procured).

4.2 ADVANCED QUALITY SYSTEM (AQS) DESCRIPTION

As previously stated, advanced quality differs from basic quality system approaches by emphasizing the prevention of defects, rather than the identification and correction of defects after the fact. While both approaches share the objective of ensuring that only material that meets customer expectations is delivered to the customer, basic quality systems tend to focus on the production phase and rely upon inspection and test (i.e., defect detection) to sort out defective material. In contrast, advanced quality (defect prevention) approaches emphasize matching the design requirements to the process limitations and then controlling the process to facilitate the production of conforming product. AQSs thus reduce waste and cycle time and enhance the predictability of manufacturing operations.

The additional confidence in design and production planning brought about by an AQS reduces development phase uncertainty in cost estimating and in design-to-cost efforts, decreasing overall program risks. It is therefore increasingly relevant to consider the

advanced quality process proposed by offerors as an important discriminator in source selection.

4.2.1 Prerequisites To An AQS

A critical enabling condition for successful deployment of an Advanced Quality System (AQS) is a defined set of contractual system performance requirements. While system requirements tend to evolve through each succeeding development phase, it is essential that the required performance characteristics be clearly specified within each request for proposal or solicitation package. Because advanced quality utilizes the systems engineering process to develop systems that meet user needs, ambiguous or missing performance specifications propagate throughout the up-front design trade-off analysis process and minimize the ability to apply advanced quality principles.

A functioning and effective basic quality system is also a prerequisite for a successful AQS. A basic quality system based on the ANSI/ASQC Q9000 series or an equivalent quality system model should be an essential feature of every aerospace acquisition program. However, in an era where aerospace systems must be both increasingly capable and affordable, aerospace community buying activities must look beyond basic quality systems and seek AQS approaches from their suppliers. Using the basic quality system as a foundation, AQSs offer reduced costs and risk through explicitly influencing the design process with manufacturing considerations. Doing so improves quality and manufacturing efficiency by reducing waste in material and labor, decreasing production cycle time, reducing the need for engineering changes, and minimizing the required overhead and sustaining engineering.

4.2.2 AQS Tools and Attributes

Since advanced quality encompasses both design and manufacturing, the advanced quality system is initially applied during the development phase (normally within an integrated product and process development framework) and focuses on achieving robust, producible designs and ensuring that manufacturing processes are controlled and capable. The objectives of the advanced quality system are achieved in a systems engineering environment utilizing a thorough knowledge of manufacturing and quality risks. While this early emphasis on quality may necessitate the application of additional resources in the development phases, the potential benefits (including decreased engineering changes, production cycle time, rework, and inspections) translate into improved life cycle affordability and reduced production transition risk.

To achieve the goal of defect prevention, advanced quality systems emphasize the optimization of the design / manufacturing process interface. An advanced quality system typically encompasses the following tools and attributes :

4.2.2.1. Integrated Product/Process Development (IPPD).

The concurrent development of the system design with the tooling, fabrication and assembly processes, manufacturing sequences, process controls, and work instructions is a necessary framework to enable the effective implementation of an

AQS. The up-front consideration of manufacturing and quality issues in the design process reduces waste and inefficiencies by precluding downstream design changes, and permits resources to be focused on those activities most important to satisfying the customer's needs.

IPPD requires the involvement of personnel from a number of functional disciplines (e.g., manufacturing engineering, production operations, quality, tooling design and fabrication, industrial engineering), including appropriate subcontractor personnel, in the design process. In an IPPD approach, design trade studies will explicitly consider quality, tooling, and manufacturing factors (e.g., manufacturing technology, fabrication and assembly costs, sources of supply, tolerances, part count, yields and verification methods) to ensure that fully informed decisions affecting these factors are made before significant resources are committed.

There are many tools for facilitating IPPD. As an example, quality function deployment (QFD) provides a structured, team-oriented planning methodology for translating the top-level customer needs into appropriate requirements at each level of product and process design. The proper application of QFD has been proven to (1) reduce overall development time, (2) reduce the number of changes required after production start, and (3) improve customer response to new products.

4.2.2.2. Identification and Control of Key Characteristics.

Key characteristics are the features of a material or part whose variation has a significant influence on product fit, performance, service life, or manufacturability. The designation of key characteristics is a valuable method for design engineers to communicate to manufacturing personnel the specific features of the design that are most important for the factory to control during manufacture and test. The designation of key characteristics also indicates to other engineers those product features that need special care when design changes are being made and can be used by manufacturing personnel to identify design features that factory data indicate are problematic. In any case, the principal benefit of identifying key characteristics is that doing so highlights those manufacturing processes -- out of the thousands that can exist in a large factory -- which should be the focus of process control and variability reduction efforts.

World class manufacturers identify each part's key characteristics on the part's drawing and on affected assembly drawings, work instructions and process specifications. Because the continuous reduction in part-to-part variation in these key characteristics is of primary importance, statistical process control techniques are used for controlling key characteristics in production.

A key characteristic must be measurable using either variable (i.e., discrete dimensions) or attribute (i.e., go/no-go) data. Key characteristics should be defined in terms of impact upon both the external and internal customers. If, for example, a characteristic results in a high internal rejection rate for the manufacturer, that

characteristic should probably be considered key. Viewed from the ultimate (external) customer's perspective, such a characteristic may not appear important; however, it is important from the internal customer's perspective because it results in rework, scrap and lost dollars. (Adapted from Boeing D6-55596 TN, Rev A, "Key Characteristics").

A number of methodologies exist to facilitate the identification of key characteristics, including analysis of historical data, Failure Modes and Effects Criticality Analysis (FMECA), and Fault Tree Analysis (the latter two methods should be applied to identification of characteristics/parameters associated with both the product and process design). QFD (see above under IPPD discussion) and design of experiments (see “Robust” Design below) can also be employed to assist in the identification of key characteristics.

Key process parameters derive directly from the key product characteristics. As manufacturing processes are designed in conjunction with design of the product, the processes that produce the key characteristics must be identified. The individual key process parameters are then identified using QFD or a similar approach so that appropriate controls and variability reduction practices (see below) can be developed and employed to ensure the final key product characteristics will conform. Once these key product characteristics and associated key process parameters are identified, process capability studies are used to verify that they can be achieved with the planned tooling and processes, or the parts or processes are redesigned as required.

Note: It is important for the purposes of this guide to distinguish between “key characteristics” and “key processes” as defined herein and the commonly used term “critical characteristic”. In general, key characteristics and key processes are associated directly with producibility and quality, whereas critical characteristics focus on personnel safety and mission performance. A critical characteristic is any feature of an end item, subassembly, material, or process for which a resulting nonconformance is likely to result in a hazardous or unsafe condition for individuals using, maintaining, or depending on same. Nonconformances in a critical characteristic can also be considered likely to prevent performance of the tactical function of a major end item such as an aircraft or weapon system.

4.2.2.3. Design to Manufacturing Process Capability.

A design policy that requires new designs to be optimized with respect to manufacturing processes is among the most fundamental of AQS design practices. All manufacturing processes exhibit variability. For processes in a state of statistical control, this variability can generally be characterized as a normal distribution (measured in standard deviations or “sigma”) about a mean value. Effective AQSs require that design tolerances be established so that manufacturing process variability falls within these limits. This relationship is measured by process capability indices (Cp, Cpk). AQSs commonly require that, as a minimum, the manufacturing processes that control key characteristics must achieve a certain minimum process capability index value. (This value typically ranges from a Cpk of 1.33 for non-complex

mechanical parts to 2.00 for parts used in complex commercial electronic systems that must exhibit extremely high reliability.)

In order to design a product to the capability of the manufacturing process that will produce it, it is imperative that that capability be understood. Depending on whether the manufacturing process is presently in use or must be developed, the process capability analysis will require using either existing historical data, designed experiments, or some method of modeling or estimating process capability. What needs to be determined is the natural variability of the process when in control (stable). Basic statistical techniques can be employed in this analysis, including tests for normality, to characterize the process and determine whether it is, in fact, under control. If not, causes of special variation must be identified and eliminated.

World class manufacturers use their knowledge of process capabilities to analyze tolerance stacking in every assembly interface area. By assessing the capability of each fabrication process and of assembly tooling, and by understanding the statistical tolerance range of each part type, the impact of worst case tolerance stackups can be assessed. Doing so allows an early influence on the design of parts, processes, and tooling that can preclude unacceptable tolerance stackups.

Prior to the initiation of production, world class manufacturers validate and verify that (i.e., “proof”) all key processes demonstrate sufficient process capability to ensure that the key characteristics for parts resulting from the process will be within the design tolerance. Validation and verification is performed in a production-representative environment, including production workers, tools, space, materials, documentation, etc. and is scheduled so that required corrective actions (such as process or tooling changes) can be accommodated, if test results dictate, in time to affect the fabrication and assembly of the first production articles.

4.2.2.4. Design for Assembly/Manufacturing (DFA/M).

DFA/M techniques are concerned with the reduction of product cost through design simplification. DFA/M achieves such simplification through parts reduction and by ensuring that the remaining parts are easy to manufacture and assemble. While not originally intended as a quality improvement technique, DFA/M usually results in significantly enhanced product quality because many nonconformances are attributable to product complexity. Defects such as missing or loose fasteners, faulty connections, and incorrectly installed parts all tend to be a function of product complexity. For each fastener or connector eliminated from the design, for example, the opportunity for one of these types of defects to occur is also eliminated. (Source: “Product Design for Assembly,” Boothroyd Dewhurst, Inc., 1991)

4.2.2.5. “Robust" Design.

The process of creating a robust design focuses on the reduction of key characteristics. A “robust” design results in a product that is insensitive to or tolerant of sources of variation and change that are difficult, costly or impossible to control. These sources

(sometimes referred to as “noise”) may include such factors as environmental conditions within a factory, minor variations in raw material, or differences in how individual customers use the product. Robust designs perform as intended despite these noise factors.

A commonly used method to achieve robustness is “parameter design,” in which the optimum parameters of key product and process characteristics (e.g., material composition, processing time, pressure, etc.) are determined such that the product is least sensitive to “noise” factors. The selection of these parameters and their settings is accomplished using statistically designed experiments, among which Taguchi fractional factorial experiments are perhaps the best known. Experience indicates that application of these techniques results in products of superior quality, while achieving significant cost reductions.

4.2.2.6. Geometric Dimensioning and Tolerancing (GD&T).

GD&T is a methodology applied to the preparation of engineering drawings or other media to more clearly describe design intent. It provides the dimensions of a component and its tolerances in a way that eliminates confusing and inconsistent notes, implied datums and incomplete specifications. One of the primary benefits of this technique is that it resolves the common engineering drawing deficiency of not identifying datum reference points from which repeatable measurements can be made. The identification of such reference points is critical to the assembly process and to understanding the impact of variation of individual components in the assembly. Despite its obvious advantages over other methods, GD&T is still not universally applied across the aerospace industrial base, hence its inclusion in this guide. The ANSI standard, Y14.5M-1982, provides instruction and ground rules for proper application of this technique. (Source: “Defect Prevention,” Appendix II, Victor E. Kane, 1989).

4.2.2.7. Process Variability Reduction (PVR).

Every production process results in some variation in the product characteristics it generates. The product characteristics may be in terms of physical, material, or chemical properties. In general terms, the product’s characteristics represent output variables of the process. Input variables are factors such as: the quality of materials used; the condition of the equipment; the training and skill of the operator; the values of nominal control settings; and the adequacy of fixtures or jigs which support and position materials. For a stable production process, the output variability is generally seen as a normal distribution about some average value. The average value may also vary with time, but in a stable process, this variation is relatively small. In the broadest sense, process control constitutes the quality assurance provisions for ensuring delivered products meet all requirements. For stable, capable processes, this generally translates to ensuring that all input variables are properly controlled with some form of feedback from output variables.

Reducing variability in key characteristics, by definition, always results in a relative benefit. The Taguchi Loss Function applies to such characteristics, showing the closer to the nominal, or target, value the characteristic is, the more reliable the product will be. PVR is a systematic approach for continuously seeking sources of variation within the key product characteristics and process parameters that control those characteristics and then developing means for eliminating the sources. Such means can include additional design improvements that would increase design robustness, eventually eliminating the applicable characteristics from the list of those considered key. After the key product characteristics have been identified, along with the key manufacturing process parameters that control them, basic statistical process control techniques can be used to ensure the processes are capable and stable (e.g., X bar/R charts).

Tools that can be used to seek out sources of variation in processes include the following.[1] :

a. Process flow charts can show the complexities within a process and interrelationships among process steps. Experience indicates that the excessive or redundant handling or movement of product, and the inefficient sequencing of process steps can be eliminated or reduced through use of process flow charts.

b. Pareto charts can help prioritize improvement opportunities identified using a variety of analytical techniques.

c. Cause and effect (Ishikawa) diagrams can also be used to help show interrelationships and prioritize improvement activities.

d. Design of experiments (DOE) analytical techniques can eliminate or control sources of variation by identifying and addressing the most influential sub-process sources of variation.

e. The Poka-Yoke or fail-safing technique involves implementation of hardware, software or monitoring instrumentation sufficient to "lock-out" or eliminate process failure modes. This approach is a fundamental defect prevention tool intended to preclude the possibility of process errors that could result in product defects.

4.2.2.8. <u>Use of stable, capable manufacturing processes as the basis for product acceptance.</u>

Once a process has demonstrated the required capability and stability, a discrete inspection or test may no longer be necessary to determine product acceptability. Rather, the product may be accepted based upon the statistical evidence collected

[1] This discussion regards improvements to stable, capable processes that aren't producing any nonconforming product. Nonconformances result from processes that are out of control and/or incapable and need to be handled with a closed loop corrective action system that identifies and eliminates their root causes.

from the process. This eliminates the cost associated with these non-value added verification activities. When a process is not capable, or is unstable, some form of inspection or test will be required to screen products that do not meet requirements. These defective products must then be reworked and re-inspected or scrapped. In any case, inspections, tests, rework and scrap add cost to the final product without adding value to it. In most cases, a stable, capable process is the preferred condition since it generally leads to the lowest cost solution. It should be recognized, however, for certain critical characteristics, movement from traditional product acceptance to acceptance by statistical evidence alone may not be prudent.

4.2.2.9. Control of variation in the measurement system. Measurement processes exhibit variation just as manufacturing processes do. For this reason, it is important that measurement equipment repeatability and reproducibility studies be conducted when performing process capability studies to ensure variation in the measurement devices variation is not consuming an excessive amount of the design tolerance. Such studies of the capability and natural variation inherent within measurement equipment are often called gage variation, or repeatability and reproducibility (Gage R&R) studies. They differ from the traditional calibration/metrology programs essentially in the details of the information obtained about the gage's accuracy, capability and reliability. Inherent variation within the gage is known as repeatability and can be measured by having one operator take repeated measurements of one characteristic on one part. Reproducibility takes into account differences between operators. Results of Gage R&R Studies are made statistically valid by controlling possibly superfluous sources of variation and in the number of trials used to obtain data. They are expressed in statistical terms and related to particular part characteristics by determining how much engineering tolerance for the characteristic is taken up by inherent gage variation.

4.2.2.10. Root cause, closed loop corrective action.
Because even an AQS will never be 100% effective in eliminating the production of defective product, some form of the material review and corrective action system used in basic quality systems is still required. However, basic quality systems have tended to place the greatest emphasis on the disposition of defective material (i.e., determining whether it should be used as is, repaired or reworked, or scrapped), and relatively little emphasis on correcting the cause of the defect. Advanced quality systems, in contrast, emphasize prevention of the defect's recurrence, whether the deficiency was found in incoming, in-process, or completed parts and assemblies. Corrective action normally involves the use of multi-functional teams and formal problem solving techniques, combined with high-level management attention and tracking. This results in evaluation and implementation of changes in designs, manufacturing processes, tooling, work instructions, training, etc., to ensure the problem does not recur.

4.2.2.11. Deployment of advanced quality system elements to subcontractors
Given that subcontractors may account for a significant percent of the work content of aerospace acquisition programs, effective implementation of advanced quality systems requires that the supplier determine those advanced quality system elements that

should be flowed down to individual subcontractors and to deploy those elements accordingly. Defect-free subcontractor products also facilitate such cost saving practices as just-in-time delivery and direct ship to assembly/stock, enabling assembly plants to eliminate redundant receiving inspection operations.

4.2.2.12. Continuous Improvement (CI)

The basic objective of CI is to constantly reduce the cost to deliver a product of increasing quality. This is achieved by assessing the root causes of both process and product variability and reducing or eliminating their influence through the institution of cost-effective changes.

Process CI: For production processes, CI initiatives may include such things as additional operator training, more frequent equipment maintenance, and refinement of control settings or improvements to fixtures. CI should also be applied to other business/management processes which, if not reliable and repeatable, may increase variability. For example, while production/manufacturing variability may be under control and constantly being reduced, out-going product quality may be compromised by ineffective quality assurance, document control, or configuration management systems. It is important that CI be focused on production, business and management processes throughout the lifecycle to ensure a cost-effective, quality product.

A tool that many companies have found useful for implementing continuous process improvement is Kaizen. This Japanese word means gradual, unending improvement. It is the systematic foundation of an organizational culture whereby all members of the organization are constantly seeking ways to perform tasks more efficiently and effectively. Kaizen results in everyone doing little things better and setting/achieving higher and higher standards. While small, individual changes may not appear to mean much, the many gradual changes that result when a company implements Kaizen often add up to significant measurable improvement over time. Kaizen implementation also often results in large, immediate improvements as the need for changes in factory layouts, product flow, etc., are discovered and implemented.

Product CI: Another aspect of CI is the evaluation of the design to determine if there are cost-effective ways to make it more robust (more tolerant to variation). As discussed earlier, design robustness can be improved through redesign, resulting in a reduction of key characteristics. As part of such an effort, designers would consider how variability associated with the factory infrastructure (inventory control, material handling, etc.) would affect the variability of product components, subassemblies, assemblies and related manufacturing/fabrication processes. The designers would then take actions to reduce such product variability through design modifications and, to the extent that robust design solutions are not cost-effective, recommend process improvements for mitigating the effects of the variability.

To facilitate CI, world-class manufacturers employ systems to collect and analyze process and product metrics which provide insight into quality, delivery, performance, cost and manufacturing efficiency. These systems use the data collected to measure effectiveness of CI initiatives as well as to identify areas for additional investigation and corrective action. These systems also can alert the supplier or customer to anticipated contract delivery schedule delinquencies, production difficulties, or delays.

4.3. ENABLING BUSINESS PRACTICES

4.3.1 Project Funding Profile

Successful implementation of AQS risk mitigation measures requires adequate up-front program funding. Many examples can be found in which government contracts have been awarded with minimal funding for leading-edge product and process design analyses and trade studies. This often results from the familiar dilemma of resolving current-year budget shortfalls while "keeping a program alive". Resources are usually found to correct the flaws of inadequate systems engineering later in the program life cycle at greatly increased cost. Program managers must be proactive in seeking and obtaining the necessary resources in the development phase to effectively implement the AQS risk mitigation measures.

4.3.2 Contract Award/Incentive Fee Pool

With acquisition reform, the traditional role of invasive government oversight of contracts is changing. The new thrust is one of government insight and contractor self governance. In order for this new way of doing business to succeed, -- i.e., for the needed change to take hold within the tradition-bound aerospace acquisition culture -- both the government and contractors may need to make some adjustments. Primarily, the government must do all it can to ensure the right contractor is chosen for the right job by increasing the rigor of source selection. The importance of past performance and contractor implementation of systems that will reduce potential risks to the quality of the product must be elevated. Once this is accomplished, however, it may also be useful to build into the contract tangible and significant incentives for world class quality in order to help ensure the chosen contractor institutionalizes the needed culture change within their company,.

Traditional incentive and Award/Incentive Fee pool structures have been based on cost, schedule and technical performance. While quality is correlated with each performance area, none of them alone captures the effectiveness of the contractor's overall quality performance. It is recommended that program managers consider establishing a fee pool specifically tied to Advanced Quality metrics. Appendix B discusses some possible methodologies in this area for consideration. However, since a wide variety of metrics and incentive arrangements can be constructed, program-unique features and constraints should drive the selection of any quality incentive structure.

5. ADVANCED QUALITY BY ACQUISITION PHASE.

This section defines the objectives of an advanced quality system and provides sample advanced quality SOO / SOW language for each of the four major acquisition phases. For the development phases, this section also provides recommended advanced quality language for RFP Sections L and M. Note that the contract language contained herein is NOT mandatory: in every case it should be adapted, modified and tailored to the extent deemed necessary for consistency with the specific conditions of the acquisition at issue. In some cases it may be necessary to add requirements for specific, program-unique defect prevention practices related to unique needs in the areas of facilities, handling, workmanship, controls (i.e., electrostatic discharge, foreign objects), etc.

5.1 DEVELOPMENT RFPs

SOO / SOWs and Sections L and M should explicitly address advanced quality using language based on that recommended herein and tailored as appropriate. Offerors should be required to provide a detailed response to Section L advanced quality issues in contractually-binding proposal instruments (local buying activity policies should dictate the circumstances under which the supplier will be allowed to unilaterally change the AQS that was proposed, and those circumstances under which buying activity concurrence must be sought). Buying activities should evaluate the proposals based on the extent to which the offeror demonstrates an understanding of, and ability in, advanced quality and proposes implementing effective advanced quality practices consistent with program needs. It is recommended that the quality element be included in the technical area under the evaluation factors for award, for two reasons: (1) The practices addressed herein are principally technical in nature; and (2) inclusion in the technical area will generally increase the influence of advanced quality practices in determining award of the contract.

5.1.1 Concept Exploration (CE) Phase, or NASA Phase A

Note: It is assumed that this phase is competitive.

5.1.1.1 CE / Phase A Objectives.

In this phase, the objective of the advanced quality system is to identify the quality risks associated with each design/technology alternative under consideration and to include those risks as factors in the process of developing the ultimate design and manufacturing solution(s).

5.1.1.2 Suggested SOO / SOW Language for CE / Phase A

The following language is suggested:

> QUALITY. The supplier shall employ an advanced quality process of their own design. The government's objective is that, through execution of the advanced

quality process, the supplier will identify the quality risks (e.g., the risks related to developing stable and capable processes, to minimizing the need for engineering changes, to preventing defects, etc.) associated with each design or technology under consideration, and identify the appropriate risk mitigation alternatives. The supplier is responsible for determining those advanced quality elements that should be flowed down to individual subcontractors, and for deploying those elements accordingly.

5.1.1.3 Suggested Section L language for CE / Phase A

The following language is suggested:

> QUALITY. Describe the planned approach for identifying the quality risks (e.g., the risks related to developing stable and capable processes, to minimizing the need for engineering changes, to preventing defects, etc.) associated with each design under consideration. Describe how knowledge of these risks will be utilized in the process of developing and refining a design solution or design alternatives. Describe the planned approach for identifying related risk mitigation alternatives. Indicate quality risk areas that have already been identified for each concept and related technologies and describe how these will be addressed.

5.1.1.4 Suggested Section M Language for CE / Phase A

The following language is suggested:

> QUALITY. Proposed approaches will be evaluated based upon:
>
> (1) The extent to which they employ disciplined, structured processes (versus ad hoc or anecdotal) for identifying and mitigating quality risks (e.g., the risks related to developing stable and capable processes, to minimizing the need for engineering changes, to preventing defects, etc.).
>
> (2) The extent to which the processes for identifying and mitigating quality risks are integrated with the overall systems engineering process.
>
> (3) The extent to which quality risk areas in proposed concepts have been identified and the assessed probability that proposed risk mitigation will be successful.

5.1.2 Demonstration/Validation (DEMVAL) Phase, or NASA Phase B

Note: It is assumed that this phase is competitive.

5.1.2.1 DEMVAL / Phase B Objectives.

In the Demonstration / Validation Phase, the objective of the advanced quality system is to define and mitigate the quality risks associated with the design solution through the development of producible designs, capable fabrication and assembly processes,

and associated controls. To achieve these objectives, subcontractors should be integrated into the supplier's initial development process.

5.1.2.2 Suggested SOO / SOW Language for DEMVAL / Phase B

The following language is suggested:

> QUALITY. The supplier shall employ an advanced quality process of their own design. The government's objective is that, through execution of the advanced quality process, the supplier will:
>
> (1) Develop and implement an approach for the identification of key product characteristics.
>
> (2) Identify quality risks (e.g., the risks related to developing stable and capable processes, to minimizing the need for engineering changes, to preventing defects, etc.) associated with the evolving design solution, and develop and implement appropriate design alternatives and risk reduction efforts.
>
> The supplier is responsible for determining those advanced quality system elements that should be flowed down to individual subcontractors and for deploying those elements accordingly.

5.1.2.3 Suggested Section L language for DEMVAL / Phase B

(Note: An integral element of the source selection process for Advanced Quality should be an assessment of the offeror's past performance in quality. It is vitally important to select a supplier with a proven record of good quality performance. The Past Performance language in Section L relative to the quality assessment would typically be consolidated with that of other areas such as cost control, program management, technical performance, etc. into a single location within Section L. For the purposes of this Guide, the Past Performance portion of Section L is left to the local buying activity's discretion and is not addressed herein.)

The following language is suggested:

> QUALITY. To describe how the quality requirements of the SOO / SOW will be met, each of the following advanced quality system (AQS) elements should be addressed. If any of the AQS elements listed below are deemed inappropriate or unnecessary for this acquisition, so note it and provide rationale for the element's exclusion. Additionally, propose and discuss any alternative AQS elements to be employed in lieu of those discussed below, as well as any additional AQS elements proposed for this acquisition. To facilitate Government evaluation of additional and alternative methods, provide rationale for each such

method, indicating how it helps to meet the SOO / SOW requirements and to satisfy the intent of the Section M paragraphs on quality.

(1) Define the proposed approach for the identification of key product characteristics. Describe how the proposed approach allocates top-level customer needs down through the design tree to individual manufacturing processes in the factory environment. Describe how the proposed approach facilitates the identification of manufacturing process and quality risks associated with the selection of product technologies.

(2) Describe how it will be ensured that existing manufacturing process capabilities are considered in the assessment of quality risks associated with the evolving product design. Define how manufacturing process and quality risk assessments are fed back to product design efforts to ensure that producibility considerations are included in the evolving product design.

5.1.2.4 Suggested Section M Language for DEMVAL / Phase B

The following language is suggested:

QUALITY. Proposed approaches will be evaluated based upon:

(1) The extent to which they employ disciplined, structured processes (versus ad hoc or anecdotal) to identify and mitigate quality risks (e.g., the risks related to developing stable and capable processes, to minimizing the need for engineering changes, to preventing defects, etc.).

(2) The extent to which the processes for identification of key product characteristics and identification/mitigation of quality risks are integrated with the overall systems engineering process

(3) The extent to which the proposed approaches reflect the integration of quality risk reduction efforts into the planning for this program.

5.1.3 Engineering and Manufacturing Development (E&MD) Phase, or NASA Phase C

Note: Low Rate Initial Production (LRIP, or NASA Phase D) is considered to be an element of this phase, and this phase is considered to be competitive.

5.1.3.1 E&MD / Phase C Objectives

The advanced quality objectives of this phase are:

a. Producible designs that fulfill specified requirements by the start of low rate initial production (LRIP) or NASA Phase D.

b. Stable, repeatable, capable fabrication and assembly processes and tooling by the beginning of LRIP or NASA Phase D.

c. Plans for controlling production processes in place by start of LRIP or NASA Phase D; implemented in LRIP or NASA Phase D

d. Plans for remediating the root cause of non-conformances in place by the start of LRIP or NASA Phase D, implemented in LRIP or NASA Phase D

e. Integration of subcontractors into the supplier's approach for achieving the above objectives.

5.1.3.2 Suggested SOO / SOW Language for E&MD / Phase C

The following language is suggested:

> BASIC QUALITY. The supplier shall implement and maintain a quality system that satisfies program objectives, including reducing risks in the areas of cost, schedule and performance, and that meets the requirements of ANSI/ASQC Q9001-1994 or an equivalent quality system model. A summary of the quality system, identifying all major processes and elements considered key to meeting program objectives, shall be made a part of the required master plan.
>
> ADVANCED QUALITY. The supplier shall employ an advanced quality process of their own design. Government expectations include review of supplier performance in satisfying the government objectives. The government's objective is that, through execution of the advanced quality process, the supplier will:
>
> (1) Identify and control the key characteristics and document those characteristics on the applicable drawing(s). (Key characteristics are the features of a material, part, or process whose variation has significant influence on product fit, performance, service life, or manufacturability. Key characteristics determine size, position, relationship, process, and functional and manufacturing features necessary to fabricate a part that meets design intent and customer requirements, and is producible by manufacturing.)

(2) Identify those fabrication and assembly processes which control key product characteristics; and verify the capability and stability of those processes using, where appropriate, statistical process control methods. These methods include determination and control of variability in the measurement system, where applicable. Production representative tooling and documentation (including process specifications and work instructions) should be employed in the verification effort sufficient to demonstrate that the required performance, quality, production rate, and manufacturing efficiency is achievable. The results of this verification, including the specific control methods and anticipated process capability indices, form the basis of controlling processes in production.

(3) Apply drawing techniques that relate the dimensions and tolerances for each part to its functions and features.

(4) Analyze and control tolerance stacking in each assembly.

(5) To the maximum practicable extent, concurrently develop the system design, tooling, fabrication and assembly processes, manufacturing sequences, process controls, and work instructions.

(6) Explicitly consider quality, manufacturing efficiency, and producibility as factors in the applicable design trade studies.

(7) Implement effective closed-loop controls for identifying and eliminating the root causes of nonconformances. The supplier should take appropriate action to change or eliminate technical requirements that nonconformance data analysis indicates are unreasonable or unnecessary, and to improve or change processes not capable of meeting requirements.

The supplier is responsible for determining those advanced quality system elements that should be flowed down to individual subcontractors and for deploying those elements accordingly.

5.1.3.3 Suggested Section L language for E&MD / Phase C

(Note: An integral element of the source selection process for Advanced Quality should be an assessment of the offeror's past performance in quality. It is vitally important to select a supplier with a proven record of good quality performance. The Past Performance language in Section L relative to the quality assessment would typically be consolidated with that of other areas such as cost control, program management, technical performance, etc. into a single location within Section L. For the purposes of this Guide, the Past Performance portion of Section L is left to the local buying activity's discretion and is not addressed herein.)

The following language is suggested:

BASIC QUALITY

(1) Describe the proposed quality system, explaining how it will be applied to reduce program risk, specifically addressing (as a minimum) the quality system's role in design and development, manufacturing planning, and key program events.

(2) Provide a relational matrix comparing, in detail, the proposed quality system with each of the elements of ANSI/ASQC Q9001-1994. Describe, in detail, any differences between the proposed quality system and ANSI/ASQC Q9001-1994.

ADVANCED QUALITY. To describe how the quality requirements of the SOO/SOW will be met, address each of the following advanced quality system (AQS) elements. If any of the AQS element listed below are deemed inappropriate or unnecessary for this acquisition, so note it and provide rationale for the element's exclusion. Additionally, propose and discuss any alternative AQS elements to be employed in lieu of those discussed below, as well as any additional AQS elements proposed for this acquisition. To facilitate Government evaluation of additional and alternative methods, provide rationale for each such method, indicating how it helps to meet the SOO / SOW requirements and to satisfy the intent of the Section M paragraphs on quality.

(1) Describe the proposed processes to be used to identify, control and reduce variability of key characteristics. (Key characteristics are the features of a material, part, or process whose variation has significant influence on product fit, performance, service life, or manufacturability. Key characteristics determine size, position, relationship, process, and functional and manufacturing features necessary to fabricate a part that meets design intent and customer requirements, and is producible by manufacturing.)

(2) Describe the proposed dimensioning and tolerancing practices to be employed in developing technical data and drawings

(3) Describe the proposed practices to be employed for analyzing and controlling assembly tolerance stacking

(4) Describe the degree of concurrency to be employed in the development of the system design, tooling, fabrication and assembly processes, manufacturing sequences, process controls, and work instructions. Describe how prime and subcontractor personnel from the manufacturing and quality disciplines will be used in the development of the design and

manufacturing processes. Discuss the use of inputs from shop personnel in the development process.

(5) Define any other general design practices and analytical techniques that will be used to enhance producibility. Substantiate how these will enhance producibility. (Producibility enhancements may include part consolidation, assembly ergonomics improvements, tooling and master model reduction, design for assembly/manufacture, etc.).

(6) Define how and when the capability of existing and planned production processes will be assessed.

(7) Describe how and when process specifications and work instructions will be validated.

(8) Describe the proposed variability control and reduction practices to be employed in production.

(9) Describe the proposed techniques to be employed for defining, identifying and controlling the fabrication and assembly processes that control key product characteristics. Discuss any training, certification, and periodic recertification that will be employed for workers, including subcontractors, that are involved with key processes.

(10) Describe the policy that will be employed in development for determining when and how to apply statistical process control, other forms of process control, and in-process inspection and test requirements in production. Describe the approach for determining when to use variable data and when to use attribute data.

(11) Describe the proposed system that will be used to assess the effectiveness of the quality system and to identify factors that may adversely impact product quality, cost, or manufacturing efficiency during production. Describe the metrics that will be collected and analyzed (may include yield rates, scrap data, rework data, etc.)

(12) Discuss the proposed plans for identifying and eliminating the root cause of nonconformances found in incoming, in-process, completed, and fielded parts and assemblies. Address the policies for identifying, documenting, handling and segregating nonconforming material, for dispositioning and investigating nonconformances for root cause, and for implementing appropriate corrective or preventive action(s).

(13) Discuss the proposed plans for identifying subcontractors to whom advanced quality requirements should be flowed. Discuss how it will be

ensured the work performed by such subcontractors meets those requirements, including the use of quality incentives and certification methods.

(14) Describe the proposed approach for ensuring the effective participation of key subcontractors in design/development and manufacturing planning processes.

(15) Describe the proposed approach for maintaining visibility of the status of subcontractor product/process development and manufacturing planning efforts and for promptly resolving problems and issues with subcontractors.

(16) Discuss how the proposed approach for assuring the quality of any work to be performed by separate divisions or other entities of your company not under your direct control.

5.1.3.4 Suggested Section M Language for E&MD / Phase C

The following language is suggested:

BASIC QUALITY. The proposed quality system will be evaluated on the extent to which it is effectively:

(1) Applied to all appropriate aspects of the program;

(2) Coordinated with other functions;

(3) Integrated into overall program planning efforts; and how it

(4) Contributes to reduction of program risk.

ADVANCED QUALITY. The proposed advanced quality approaches will be evaluated on the extent to which they are adequate for program needs and meet the following criteria:

(1) The extent to which the proposal reflects the integration of the advanced quality approaches into the planning for this program. This includes the integration of subcontractors into the approach for achieving the advanced quality objectives. The proposed timing of these activities and tasks will be assessed for the extent to which it facilitates accomplishment of the following prior to LRIP:
- Producible designs
- Stable, capable processes
- Plan for controlling production processes
- Plan for remediating the root cause of non-conformances.

(2) How well the proposed approaches contribute to manufacturing, quality, cost and schedule risk reduction.

(3) How well the proposed approaches facilitate the prevention (versus detection and correction) of defects.

5.2 FULL PRODUCTION PHASE

Note: The RFP for this phase is assumed to be sole source.

5.2.1 Full Production Phase Objectives.

The advanced quality objectives of the full production phase are:

a. Stable, repeatable, capable fabrication and assembly processes and tooling.

b. Effective production process controls in use.

c. Use of an effective system for remediating the root cause of non-conformances.

d. Integration of subcontractors into the supplier's approach for achieving the above objectives.

5.2.2 Suggested Full Production Phase SOO / SOW Language.

SOO / SOWs should include language similar to the following:

> BASIC QUALITY: The supplier shall implement and maintain an ANSI/ASQC Q9001-1994, or equivalent, quality system that satisfies program objectives, including reducing risks in the areas of cost, schedule and performance. A summary of the quality system, identifying all major processes and elements considered key to meeting program objectives, shall be made a part of the required master plan.
>
> ADVANCED QUALITY. The supplier shall employ an advanced quality process of the supplier's own design. Government expectations include review of supplier performance in satisfying the government's objectives. The government's objective is that, through execution of the advanced quality process, the supplier will:
>
> (1) Control the fabrication and assembly processes that affect key product characteristics to maintain or improve their capability and stability.
>
> (2) Explicitly consider quality, manufacturing efficiency, and producibility as factors in any product / process studies.

(3) Implement effective closed-loop controls for identifying and eliminating the root causes of nonconformances. Appropriate action should be taken to change or eliminate technical data requirements that nonconformance data analysis indicates are unreasonable or unnecessary, and to improve or change processes not capable of meeting requirements.

The supplier is responsible for determining those advanced quality system elements that should be flowed down to individual subcontractors and for deploying those elements accordingly.

APPENDIX A

JACG POLICY DOCUMENTS ON BASIC QUALITY

DEC 12 1994

From: Commander, Naval Air Systems Command
Commander, Aeronautical Systems Center
Commander, Army Aviation and Troop Command
Commander, Defense Logistics Agency

Subj: POLICY FOR THE USE OF ANSI/ASQC Q9000 SERIES QUALITY STANDARDS

Ref: (a) USD(AT) memo of 14 Feb 94, Subject: Use of Commercial Quality System Standards in the Department of Defense
(b) SECDEF memo of 29 Jun 94, Subject: Specifications and Standards - A New Way of Doing Business
© Joint Aeronautical Commanders Group ltr Ser 0078, of 31 Jan 94, Subject: Interim Policy for the Use of ANSI/ASQC Q9000 Series Quality Standards

Encl: (1) JACG Policy for the Application of Q9001, Q9002 and Q9003
(2) Points of Contact

1. Enclosure (1) promulgates implementing guidance for the policies of references (a) and (b). This letter supersedes the Naval Aviation Systems Team and Aeronautical Systems Center policy issued under reference (c).

2. Points of contact for ANSI/ASQC Q9000-Series policy are found in enclosure (2).

RICHARD M. SCOFIELD
Lieutenant General, U. S. Air Force

W. C. BOWES
Vice Admiral, U. S. Navy

JOHN S. COWINGS
Major General, U.S. Army

LAWRENCE P. FARRELL, JR.
Major General, U. S. Air Force

Subj: POLICY FOR THE USE OF ANSI/ASQC Q9000 SERIES QUALITY STANDARDS

Distribution:
ASC 2A
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Navy PEO(T)
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Commander, NAWC-AD Trenton
Commander, NAWC-AD Lakehurst
Commander, NAWC-AD Indianapolis
Commander, NAWC-WD Point Mugu
Commander, NAWC-WD China Lake
Commander, NAWC-TSD Orlando

JACG POLICY FOR THE APPLICATION OF Q9001, Q9002, AND Q9003

1. General Policy. The following American National Standards Institute/American Society of Quality Control (ANSl/ASQC) documents are authorized for use by JACG military buying activities in all new contracts, in accordance with the policies defined herein.

ANSI/ASQC-Q9001	“Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing”
ANSI/ASQC-Q9002	“Quality Systems - Model for Quality Assurance in Production and Installation"
ANSI/ASQC-Q9003	“Quality Systems - Model for Quality Assurance in Final Inspection and Test”

Q9001, Q9002, and Q9003 are the U.S. equivalents of the international quality standards ISO 9001, 9002, and 9003, respectively. The policies herein apply equally to both the Q9000 series documents and the predecessor Q90 series documents.

2. Contractual Implementation. The SECDEF memo of 29 Jun 94, entitled "Specifications and Standards -- “A New Way of Doing Business" requires buying activities to seek waivers for the use of military specifications and standards from the Milestone Decision Authority. This policy also states that waivers for reprocurement of items already in the inventory are not required. Per these policies, JACG military buying activities shall no longer include requirements for MIL-Q-9858A and MIL-I-45208A in requests for proposal (RFPs) for new systems or equipment. For new domestic RFPs, JACG military buying activities shall instead require contractors to implement a quality system that conforms to ANSI Q9001, Q9002, or Q9003 (as appropriate) or an equivalent quality system model that satisfies program objectives (The international equivalents, ISO 9001, ISO 9002, and ISO 9003 may be used for new international contracts with non-NATO countries. However, DFARS Subpart 246.406, STANAG 4108, requires the use of the Allied Quality Assurance Publication (AQAPs) for new contracts with NATO countries.)

In implementing this policy in competitive RFPs, JACG military buying activities may consider the following suggested language for the Statement of Work (SOW), Section L, and Section M. (While the example language that follows is structured for a development phase RFP, it is adaptable for production phase RFPs.)

Suggested SOW language for a quality system requirement. "The contractor shall implement and maintain a quality system that satisfies program objectives and meets the requirements of Q9001 or an equivalent quality system model.

Suggested Section L language. "Offerors shall propose a quality system that satisfies program objectives and meets the requirements of Q9001 or an equivalent quality system model. Offerors shall:

a) Describe the proposed quality system, explaining how it will be applied to reduce program risk, and specifically addressing (as a minimum) the quality system's role in design and development, manufacturing planning, and key program events.

b) Provide a relational matrix comparing, in detail, the proposed quality system with each of the elements of Q9001. Describe, in detail, any differences between the proposed quality system and Q9001 "

Suggested Section M. language. "The offeror's quality approach will be assessed based on the effective:

a) application to all appropriate aspects of the program;
b) coordination with other functions;
c) integration into overall program planning efforts; and
d) contribution to reduction of program risk."

Offeror ability to satisfy the quality system requirements shall be assessed in source selection and continuously monitored after contract award. The source selection criteria shall include quality, and the buying activity shall evaluate whether proposed quality systems do or do not satisfy program objectives. For existing contracts, JACG military buying activities shall not unilaterally modify existing contracts to use Q9001, Q9002, or Q9003. However, buying activities shall approve contractor requests to use the Q9001, Q9002, or Q9003 standards where doing so fulfills the needs of both parties.

3. Augmentation. JACG military buying activities shall encourage contractors to implement an "advanced. quality system. While "advanced. quality is the subject of a current JACG policy development initiative, elements of an "advanced" quality system can be considered to include identification and control of key characteristics, analysis of new and key manufacturing processes, variability reduction initiatives, and root cause corrective action systems. Ultimately, it is the goal of the JACG to assure quality through design practice and controlled manufacturing processes. To that end, as JACG military buying activities prepare new joint product specifications, they will include provisions for acceptance of controlled manufacturing processes as an

alternative means of verification to traditional inspection and test in Section IV of the specifications.

4. Other quality requirements. Risk, design complexity and maturity, process complexity and maturity, safety, and economics should also be assessed in decisions relative to the contractual applicability of other quality requirements. Buying activities that have historically employed additional requirements for their unique commodities (such as requirements for subcontractor control, nonconforming material control, software quality, and flight safety parts quality) should continue to employ these requirements when appropriate. However, local direction governing the use of military-unique, restrictive, or prescriptive requirements should be heeded in formulating the requirements. If a quality plan is deemed necessary for a JACG military contract, the statement of work and contract data requirements list shall reflect that requirement.

5. Training. Acquisition management and technical personnel in JACG military buying activities shall receive suitable training or instruction on the Q9000 series standards. Contracting officers shall consult with quality personnel trained in the Q9000 series before including these standards on contract. Quality personnel shall understand program office and industrial base impacts before utilizing commercial or military specifications and standards for quality.

6. Government Rights. The standard inspection clause and all other standard FAR and DFARS clauses shall be included on all JACG military buying activity contracts where Q9001, Q9002 or Q9003 is applied. As required by FAR Part 461DFARS Part 246 and the standard inspection clauses in FAR Part 52.246, all contracts, regardless of the type of quality requirements specified, shall retain the government's right to inspect, accept, and reject supplies and services, and to disapprove a contractor's quality system if it fails to meet contract requirements

7. Third party quality system registration. Contracting officers shall not place a requirement for third party quality system registration to Q9001, Q9002 or Q9003 on JACG military contracts. The presence or absence of a registered quality system shall not be a factor in determining the extent of quality system surveillance at the prime or subcontractor levels. In no case will the government surrender its rights under the standard inspection clause. The existence of a registered quality system does not exempt the contractor from any contractual design, performance, or quality responsibilities. The determination of the adequacy of a contractor's quality system in meeting contract requirements is the responsibility of the JACG military buying activity and contract administration services (CAS).activities.

8. Coordination with Contract Administration Services (CAS). Prior to release of a request for proposal, or following contract award, buying activity and CAS activity

personnel shall agree on the administration of the quality system requirements. If appropriate, a memorandum of agreement or governmment quality surveillance plan shall be enacted between the JACG military buying activity and the cognizant CAS activity to define the administration methodologies associated with Q9001, 09002 or Q9003.

NASA MANAGEMENT INSTRUCTION

NMI 1270.3
Effective Date December 6, l995
Expiration Date December 6, 1999

Responsible Office: Q/Office of Safety and Mission Assurance

Subject: NASA QUALITY MANAGEMENT SYSTEM POLICY {ISO 9000)

1. PURPOSE

This Instruction establishes the policy for the use of the International Organization for Standardization's “ISO 9000" Quality Management System Standards by NASA and NASA suppliers. Incorporation of the ISO 9000 Standards into NASA and NASA-supplier processes that affect the quality of deliverable products and processes will result in mission success and promote optimum use of available resources, increase productivity, facilitate timely delivery, encourage cost effectiveness, heighten environmental concern, solicit innovation and continuous improvement, and ensure corrective action.

2. APPLICABILITY

This Instruction applies to NASA Headquarters, NASA Centers, and NASA suppliers whose processes affect the quality of deliverable products and services. ISO 9000 lmplementation is optional for all contracts in existence as of the effective date of this Instruction and for Construction of Facilities, Institutional Support Services, off-the-shelf items, Department of Defense bailed aircraft, and noncomplex, noncritical, ground-support equipment and commercial items.

3. SCOPE

NASA and NASA-supplier quality management systems for hardware, software, and services for designing, developing, producing, installing, operating, and servicing activities are subject to the provisions of this Instruction.

4. DEFINITIONS

For the purposes of this Instruction, definitions contained in the Federal Acquisition Regulation, Part 46, “Quality Assurance,” and ISO 8402, "Quality Management and Quality Assurance - Vocabulary,” apply.

5. POLICY

It 18 NASA policy to require that NASA and NASA suppliers have a Quality Management System. That system, as a minimum, shall comply with the appropriate standard contained in the current version of the International Organization for Standardization's "ISO 9000" Standard Series or the American National Standards Institute/American Society for Quality Control's “Q9000 Series” and associated documentation. The ISO 9000 Quality System Requirements may be tailored. or supplemented as necessary by the procuring activity, to ensure that all applicable requirements for NASA procurements are met and that unnecessary requirements are not imposed. Registration/certification is optional on the part of the procuring Organization, and the criteria for determining compliance with this Instruction will be established by the procuring Organization.

6. RESPONSIBILITY

a. The Administrator has ultimate responsibility for the quality of all NASA programs. The Associate Administrator(AA) for Safety and Mission Assurance, or designee, is the management representative responsible for NASA's Quality Management System.

b. Quality assurance is an in-line function at every level of management from the Program AA down to the Project Official-in-Charge and down to the lowest level of management. Each level of management has a responsibility for upward and downward enforcement of this Instruction.

c. NASA Center Directors and the Jet Propulsion Laboratory Director have the authority, accountability, and responsibility for implementation and oversight of this Instruction at their Centers.

d. The Office of Safety and Mission Assurance is responsible for facilitating, providing implementation guidance, training, and oversight of this Instruction throughout the Agency,

7. CANCELLATION

NMI 1270.2B, dated December 22, 1992.

Administrator

DISTRIBUTION:
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APPENDIX B

INCENTIVES

One of the intended outcomes of an advanced quality system is continuous improvement to reduce risks and improve program cost, schedule and technical performance. An added benefit of continuous improvement is often improved product reliability as design robustness is increased and process variability is reduced. However, mandating continuous improvement systems in government contracts has often proven to be ineffective without specific contractual incentives. Government contractors simply do not face the same marketplace pressures that drive continuous improvement as commercial companies. Even a practice widely recognized to be beneficial -- variability reduction -- might be implemented in an ineffective manner unless adequate incentives are provided to ensure contractors and subcontractors want to develop and implement improvements because it is in their best financial interest to do so. Coupled with the fact that contractual language will no longer dictate methods, but instead rely on contractor processes for meeting contractual product technical performance requirements, incentives to improve those processes become more important. For these reasons, it is suggested that the implementation of appropriate monetary incentives be considered through the use of contractual Award/Incentive Fee criteria.

Award/Incentive Fee criteria ought to be program-unique, taking into account the mission of the program, the product's key characteristics, capability of the contractor(s) and other unique features of the program. They also ought to be jointly developed and negotiated with the contractor(s), government plant representatives, and users to ensure the buy-in of all stake-holders, which in turn will help ensure appropriate resources are applied to the improvement efforts. In addition, soliciting inputs from the user community for the product will strengthen the critical early communication link between the user, the program office and the contractor. It may also have the added benefit of helping to identify what the users feel is most important, a critical determination in identifying key product characteristics. The following attributes of good incentive criteria need to be kept in mind when developing Award/Incentive Fee criteria:

1. They must be relevant to the program and consistent with program mission, goals, operational requirements, etc.

2. They must be consistent with contract requirements and other program documents.

3. They must be measurable and the measurement systems must be reliable, comprehensive and trustworthy.

4. They must be beneficial to both parties. In other words, the benefits to be derived by the government must outweigh all costs, including administration of the Award/Incentive Fee plan, and the potential benefits for the contractor must make it worth their while to put appropriate effort into finding ways to improve current performance.

5. Taken as a whole, they should incentivize continuous improvement. In other words, they shouldn't have an end point goal, which, when achieved, will result in termination of the improvement effort prior to the end of the Award/Incentive Fee period due to lack of incentive to continue. Although it may be useful to have individual criteria that incentivize accomplishment of some task (e.g., identification of all key characteristics on drawings), there should be sufficient additional criteria to incentivize continuous improvement.

6. Related to the last 2 points, the criteria should reflect "stretch" goals that challenge the contractor but are also achievable.

7. They should not be "etched in stone" but should allow for review and renegotiation. This is especially true for criteria incentivizing complete accomplishment of particular tasks as discussed under 5, above.

Rating categories should be defined to determine the amount of Award/Incentive Fee that will be paid based on the contractor's performance in defined criteria over a defined period of time. Due to the fact that no matter how well planned, incentive criteria may not produce the desired results because they are too difficult or too easy to attain or because they simply don't reflect actual contractor performance, flexibility should be built into the incentive system. One means of doing this is for the rating criteria to provide the Fee Determining Official with some leeway (a range) to determine the exact amount of the fee to be awarded. An example might be as follows:

RATING	PERCENT OF POSSIBLE AWARD/INCENTIVE FEE TO BE PAID
Excellent	91 - 100
Good	71 - 90
Satisfactory	51 - 70
Marginal	1 - 50
Unsatisfactory	0

Award/Incentive Fee criteria can be developed for any useful metrics in accordance with the attributes of good criteria noted above. It is recommended that a variety of

metrics be used to provide a more comprehensive depiction of true quality program performance and to prevent over-emphasis on a particular measure at the expense of others. For each metric, cost, schedule and/or performance goals can be developed and incentives applied for progress toward or beyond them. In addition, it may be useful to connect metrics together so that, for example, poor performance in one area will prevent award of fees in other areas until performance is at a minimal level across the board.

When considering metrics to be used as incentives criteria, it is important to determine what behaviors outside of the norm are desired. For example, the attributes of an Advanced Quality System which would be helpful for ensuring success of any particular program could be considered for incentivization. The table on the following page provides examples of metrics that may be developed and used for incentivizing implementation of advanced quality system attributes. Note that these are essentially process oriented metrics. Individual programs may want to incentivize product performance attributes as well.

In addition to those suggested in the table, other possible Award/Incentive Fee criteria can include value-engineering incentives for changes that make designs more robust, improve first-pass test yields, increase management responsiveness, make progress toward training goals, etc. Another source of information are the weighted guidelines for negotiating profits found in the Defense Supplement to the Federal Acquisition Regulations. These could be adapted to reward affordability improvements.

ADVANCED QUALITY SYSTEM PERFORMANCE ATTRIBUTES	ASSOCIATED CANDIDATE METRICS FOR AWARD/INCENTIVE FEE CRITERIA
Design practices result in the identification, documentation and control of key product characteristics	- Percentage of drawings for which key characteristics have been identified - Percentage of key characteristics for which control methods have been defined
Design practices result in robust designs that are insensitive to variability in manufacturing processes and minimize part complexity	- Average number of key characteristics per drawing - Part complexity index value or design efficiency value (from Design-for-Assembly/Design-for-Manufacture analysis) - Percentage of critical failure modes among all failure modes (include both product and process FMECA)
Design practices minimize tolerance stack-up, interference and assembly alignment problems	- Percentage of drawings developed using geometric dimensioning and tolerancing techniques
The Advanced Quality System facilitates the use of stable, capable manufacturing processes as a basis for product acceptance in lieu of inspection and test	- Percentage of key characteristics to be controlled by existing, fully characterized manufacturing processes - Percentage of part numbers accepted on basis of manufacturing process capability - Appraisal costs (i.e., inspection and test) as a percentage of total quality costs (prevention, appraisal and failure)
The Advanced Quality System ensures that manufacturing processes and tooling controlling key product characteristics (i.e., "key" processes) are stable and capable	- Percentage of key processes with Cpk values at 1.33 or higher or with equivalent means of process control (e.g., adaptive machine control, poka yoke (mistake proof) control, etc.)
The Advanced Quality System ensures that variation associated with measuring and test equipment is accounted for when determining process capability	- Percentage of key manufacturing processes not already demonstrated to be stable and capable on which gage repeatability and reproducibility studies have been performed
The Advanced Quality System facilitates (1) the rapid disposition of defects; (2) rapid and accurate identification of the root causes of defects; and (3) the implementation of effective corrective action	- Number of repeat nonconformances - Number of open nonconformance investigations - Age of nonconformance investigations - Average disposition time per nonconformance - Percentage of "use-as-is" dispositions - Failure (e.g., scrap, rework and repair) costs as a percentage of total quality costs (prevention, appraisal, failure)
The Advanced Quality System facilitates continuous variability reduction for key product characteristics and processes	- Cpk values, yield rates or defects per million opportunities for selected characteristics and processes over time
Suppliers are fully integrated into the Advanced Quality System	- Percentage of suppliers who are certified for ship-to-assembly/stock - Percentage of supplier items subject to re-inspection upon receipt - Percentage of nonconformances (and/or failure costs) attributable to suppliers

NOTE ON KEY CHARACTERISTICS AND OTHER SIMPLE "BODY COUNT" METRICS: Although it is important that all key characteristics be identified, the fewer there are, the more robust the design will be. For this reason, it may be helpful to develop incentive criteria such as those suggested for reducing key characteristics previously identified. Of course, with all incentives utilizing simple counts (e.g., defects), it is important to balance out such criteria to prevent artificial inflation of early measurements for the purpose of making it easier to show incentivized improvements later on.

Following are two specific examples of Award/Incentive Fee criteria to show how they might be developed. Their specific applicability to any particular program will depend on attributes of the program, as discussed earlier in this appendix (attributes of good incentive criteria).

EXAMPLE CRITERION 1: Product Variability Reduction:

BASIS FOR DETERMINATION: Selected manufacturing processes are agreed upon by the contractor and buying activity. Statistical data will be collected on these identified processes to determine the control limits based on the statistical capabilities of each process. A process capability index (Cpk) will be measured by taking into account the tolerance limits for the process outputs. A rating will be determined by comparing the measured Cpk with the evaluation criteria shown below. No Award/Incentive Fee will be given for any process until all key processes have a Cpk of 1.00 or greater at the end of the rating period. Once all identified key processes meet this requirement, an Award/Incentive Fee amount will be determined for each identified process that has a Cpk of 1.33 or greater based on the monthly average Cpk of the process for the applicable period. (NOTE: sample sizes and the frequency of determining Cpk each month, so that an average Cpk can be determined, must be agreed to for each process based on statistical data).

EVALUATION: The following factors will be used to determine the amount of Award/Incentive Fee the contractor is entitled to:

Ratings:

Excellent:	Cpk > 2.00
Good:	Cpk = 1.67-1.99
Satisfactory:	Cpk = 1.50-1.66
Marginal:	Cpk = 1.33-1.49

Note in this example that it was set up to require both a minimum level of performance across the board (all key processes must be at a Cpk of 1.0 or greater for any fees to be paid), as well as individual payments for each process having a Cpk above what is widely accepted as the minimum acceptable process capability of 1.33. (Questions such as those regarding the appropriateness of paying an additional fee for “marginal” performance can easily be handled with a change in terminology.) Note, too, that the incentive here might be to reach the minimum in the “Good” category (1.67) but beyond that, due to the larger range before the next level is reached, it may be determined not to be worth the extra

effort required to reach the “Excellent” category. Something like this could be done intentionally to try to get contractors to bring all their processes to a desired level of performance, rather than concentrating on one or two easy ones, while still providing some incentive for even further improvement. Other possibilities might be to negotiate different levels for different processes or categories of processes. When negotiating criteria, buying activity personnel should keep in mind what it is they want to achieve with the particular incentive. In addition, of course, criteria such as this one would necessitate correct application of the statistical concepts, such as verification that the applicable processes have normal distributions, correct sampling techniques, agreed-upon confidence levels, etc.

EXAMPLE CRITERION 2: Cost of Quality.

BASIS FOR DETERMINATION: A detailed Cost of Quality (COQ) measurement system is developed and agreed to between the buying activity and contractor. A baseline study will determine initial values for each of the COQ categories (prevention, appraisal, internal failure and external failure costs) and the agreed upon comparison base (e.g., Sales, Value-added Direct Labor costs, etc.). Each month, the COQ data will be collected and categorized. Various comparisons for identifying improvements will be made and separate Award/Incentive Fees paid for each as shown below.

A. The total costs of quality will be compared with the base costs each month of the Award/Incentive Fee period. Fees will be awarded based on the following:

EVALUATION: The following factors will be used to determine the amount of Award/Incentive Fee to which the contractor is entitled (note: the first period will be compared only with the baseline study):

Ratings	**As a percent of the base, total COQ was reduced:**
Excellent:	20% or more from the previous period.
Good:	10 - 19% from the previous period.
Satisfactory:	5 - 9% from the previous period.
Marginal:	1 - 4% from the previous period.

B. Each of the COQ categories will be compared with the total COQ each month of the Award/Incentive Fee period and with previous periods (the first period will be compared with the baseline only). Fees will be awarded based on the following:

EVALUATION: The following factors will be used to determine the amount of Award/Incentive Fee the contractor is entitled to:

Ratings:

Excellent: No external failure costs were reported for the entire period and both of the following occurred: (1) average monthly appraisal costs were <30% of the average monthly total COQ and (2) average monthly internal failure costs were reduced by at least 10% over the previous period.

Good: No external failure costs were reported for the entire period and both of the following occurred: (1) average monthly appraisal costs were <40% of the average monthly total COQ and (2) monthly internal failure costs were reduced by at least 10% over the previous period.

Satisfactory: No external failure costs were reported for the entire period and average monthly internal failure costs were reduced by at least 10% over the previous period.

Marginal: No external failure costs were reported for the entire period.

In this example, it would be unacceptable to have any failures discovered by an external customer, which, of course, can be achieved by increasing appraisal costs (inspections and tests). For this reason, additional incentives are applied to reduce appraisal costs. Note that, as internal failure costs go down, all else being equal, total COQ will go down and since appraisal costs are measured as a percent of the total, they must also decrease to get one of the higher ratings. However, since the desire is to have contractors transfer effort into prevention activities, further criteria may be needed to prevent implementation of nothing but a “find and fix” appraisal oriented system that keeps internal failures high without requiring reduced appraisal costs. As a minimum, a comprehensive root cause eliminating corrective action system would be needed. Note also that although an increase in prevention costs might increase total COQ temporarily, making it unnecessary to decrease appraisal costs to meet one of the higher rating criteria, a reduction in internal failures will be the inevitable result of increased prevention activity. Total COQ will go down when fewer defects are created, which further justifies reduced appraisal.

In order to obtain the greatest possible benefit, incentives utilizing COQ should be based on a comprehensive system that collects most non-value-added costs (non-direct labor costs). Although the administrative burden of ensuring implementation of such a comprehensive data collection system may seem high, the potential advantages may make such incentives worthy of consideration. For instance, by accurately identifying the “hidden factory” that still exists in most companies, major breakthroughs in reducing non-value-added costs can be achieved. In addition, Cost of Quality systems provide the best possible Pareto data for identifying those areas having the largest potential payback. Other possible comparisons utilizing such a system would be between prevention, appraisal and internal failure costs.

APPENDIX C

GLOSSARY OF SELECTED KEY TERMS

Advanced quality system (AQS). A quality system that builds on a basic quality system by emphasizing a development phase influence and by focusing on preventing defects.

Basic quality system. A quality system based on MIL-Q-9858A and the ANSI/ASQC Q9000 / ISO 9000 series.

Geometric Dimensioning and Tolerancing (GD&T). A methodology applied to the preparation of technical data to clearly describe design intent by providing the dimensions of a component and its tolerances in a way that eliminates confusing and inconsistent notes, implied datums and incomplete specifications.

Integrated Product/Process Development (IPPD). The concurrent development of the system design with the tooling, fabrication and assembly processes, manufacturing sequences, process controls, and work instructions

Joint Aeronautical Commanders Group (JACG). A body chartered under the aegis of the Joint Logistics Commanders and composed of the heads of the aeronautical buying activities of each service, DCMC, NASA, and the Coast Guard.

Key Characteristics. The features of a material or part whose variation has a significant influence on product fit, performance, service life, or manufacturability.

"Robust" Design. A design process that focuses on the reduction of key characteristics.

Subcontractor: A contractor with whom the prime contractor in a government contract has contracted for services or products.

Supplier: As viewed by the government buying activity, the prime contractor in a contract.

ADVANCED QUALITY POINTS OF CONTACT

Points of contact for Advanced Quality policy are as follows:

Naval Air Systems Command	Mr. Bob Tourville, AIR-4.1.9 (703) 604-6060 x 5679
USAF Aeronautical Systems Center	Mr. Bob Craven, ASC/ENS (513) 255-7126 x 215
Army Aviation and Troop Command	Mr. Kent Nelson, AMSAT-A-TD (314) 263-3427
Defense Contracts Management Command	Mr. Richard Zell, AQCOG (703) 767-2413
United States Coast Guard	Mr. Augi Rios, G-A08 (202) 267-2827
National Aeronautics and Space Administration	Mr. Steve Newman, Code Q (202) 358-1408

Enclosure (2)